THE NATURE OF *ACICULELLA* PIA (CALCAREOUS ALGAE)

by GRAHAM F. ELLIOTT

ABSTRACT. The dasycladacean alga *Aciculella ogilvie-gordonae* sp. nov. is described from the Upper Permian of northern Italy: the first Permian record of a hitherto Triassic genus. Julius Pia's type-description of *Aciculella* as an originally calcified endospore stem-cell filling, and not an acicularian spicule, is examined in the light of subsequent research and of fresh evidence from the Permian fossil, and is confirmed. Records of *Aciculella*, including some possible new species, are summarized. It is concluded that the endospore stem-cell fillings referable to *Aciculella* are possibly of diverse generic origins.

Aciculella is a somewhat problematic microfossil, recognized by Julius Pia as dasycladacean in origin and named by him probably on account of resemblance to *Acicularia*. The morphology of *Aciculella* is simple and not ambiguous; the interpretation to be accorded to the structures seen, as remains of a former living alga, is difficult. Pia (1927) gave an excellent diagnosis of the genus, and somewhat characteristically named but did not describe or figure the type-species *A. bacillum*, which came from the Middle Triassic (Ladinian Stage) of the Central European Carpathians. This deficiency he remedied later (Pia 1930) when describing other problematic dasycladacean remains, in part comparable.

During a recent examination of algal limestones in the Ogilvie-Gordon collection in the British Museum (Natural History), I was surprised to find a Permian species of *Aciculella* in the Upper Permian Bellerophon Limestone from northern Italy. The preservation of this little fossil, and its association in the same rock with another problematic endospore alga, permits a re-examination and clarification of the problem. To facilitate subsequent discussion, the new species is described first.

SYSTEMATIC PALAEONTOLOGY

Order DASYCLADALES (Pascher) Feldmann 1938
Family DASYCLADACEAE Kützing orth. mut. Stizenberger 1860
Genus ACICULELLA Pia 1927

Diagnosis (after Pia). Cylindrical solid calcareous rod or baton, without central tubular perforation, but with numerous subperipheral globular cavities, each opening externally by a pore. Considered to be the stem-cell filling of an otherwise uncalcified endospore dasycladacean.

Type species. A. bacillum Pia; Middle Triassic (Ladinian) of Central Europe.

Aciculella ogilvie-gordonae sp. nov.

Plate 118, fig. 1; Plate 119, figs. 1, 2, 5

Diagnosis. Aciculella differing from the type-species in that the peripheral cavities are

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smaller, more numerous, crowded, and ovoid or subdeltoid, rarely spherical. These differences are summarized below.

	A. bacillum	*A. ogilvie-gordonae*
Length	—	2·03 mm+
Diameter	0·4–0·7 mm	0·4–0·5 mm
Diameter of cavity	0·1 mm; spherical	0·07–0·08 mm; ovoid or subdeltoid
Number of cavities on cross-section	15	24 approx.

Description. Solid cylindrical rod or baton, circular in cross-section, with length of 2·03 mm (incomplete) and diameters of 0·4–0·5 mm seen. The material forming the rod is coarse yellow-tinted crystalline calcite; the matrix of the rock outside is finely crystalline greyish calcite. Immediately within the outer periphery, as seen in both vertical and transverse section, the rod is lined with numerous closely-set ovoid bodies, often widening from within outwards (subdeltoid), and only rarely spherical. They show diameters of 0·07–0·08 mm, and are closely set, often with interstices of only 0·01 mm across. When irregular in shape they have a crowded appearance. These bodies are usually filled with very dark, very finely crystalline calcite, much finer in grain than that of the matrix. The dark colour may be due to original plant matter. Careful examination shows that the yellow calcite often extends between the peripheral bodies, but that sometimes the grey calcite of the matrix, whether due to the surface being worn originally or to later replacement, extends inwards for a short distance between them. Very rarely an occasional ovoid body is to be seen centrally in the main calcite filling; this phenomenon was also noted by Pia in *A. bacillum*.

Associated fossils are very numerous small foraminifera, rolled pieces of the codiacid alga *Tauridium*, recognizable by its distinctive thread-pattern, pieces of the dasycladacean

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EXPLANATION OF PLATE 118

Fig. 1. *Aciculella ogilvie-gordonae* sp. nov. Holotype: longitudinal thin-section, slightly oblique, ×48. Marginal sporangial bodies embedded in a common mass of organic calcium carbonate. Upper Permian, Bellerophon Limestone; Plesch d'Inez, Grödener Valley, South Tirol, N. Italy. Brit. Mus. (Nat. Hist.) Dept. Palaeont., Reg. no. V.53904.

Fig. 2. *Acicularia* (*Briardina*) sp. Thin-section of spicule, ×60. Palaeocene-Lower Eocene, Sahil Maleh, Batinah Coast, Oman, Arabia. Reg. no. V.52033.

Fig. 3. *Atractyliopsis dararіensis* Elliott. Longitudinal thin-section of fragment, ×40. In this genus the marginal sporangial bodies seen in *Aciculella* have their own individual coatings of organic calcium carbonate. Upper Permian, Darari Formation; Ora, Mosul Liwa, N. Iraq. Reg. no. V.52037.

Fig. 4. *Acetabularia* sp. 'The Mermaid's Wine-glass', ×4·5. The disc or cup is built of fused radial calcified elements, each of which is somewhat similar to the single spicule seen in fig. 2 above. Recent. Tunis, N. Africa.

Fig. 5. *Diplopora phanerospongia* Pia. Oblique-transverse thin-section, ×24. A species in which calcified sporangial bodies, marginal in the stem-cell as in *Aciculella* and *Atractyliopsis*, are encased in the calcified detail of the verticillate branches of the plant, which were not calcified in the other two genera. Upper Triassic, derived in Upper Cretaceous Hawasina Formation, Oman, Arabia.

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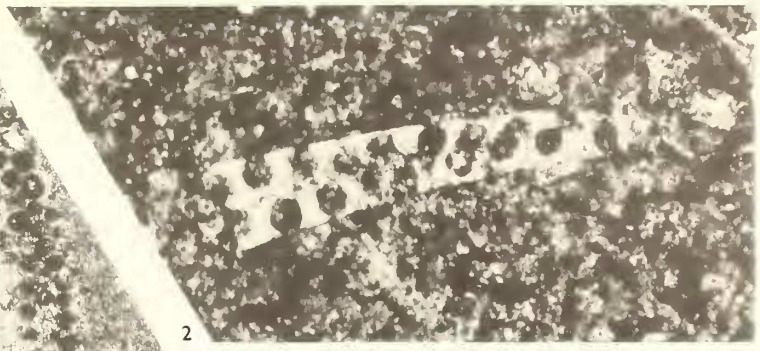

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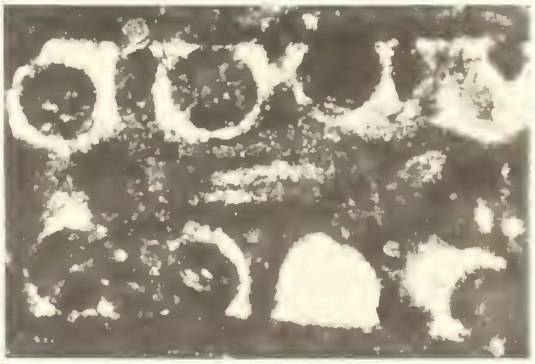

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ELLIOTT, *Aciculella* Pia

Atractyliopsis lastensis Accordi, small rolled radiate growths of a myxophyte thread-alga, and occasional examples of the microproblematicum *Aeolisaccus dunningtoni* Elliott. This is for the most part a size- and density-sorted assemblage of small organic objects gently rolled and accumulated in shallow water not far from the place of growth of the algae. One small example of *A. dunningtoni* (Elliott 1958), now known to range from Permian to Lower Cretaceous, appears to show a tiny initial spherical structure, not seen in larger examples (Pl. 119, fig. 3). This supports the view that these ubiquitous little microfossils may have been pelagic in origin.

Holotype. The specimen figured in Pl. 118, fig. 1, from the Bellerophon Limestone, Upper Permian; Plesch d'Inez, Grödener Valley, S. Tirol, N. Italy (Ogilvie-Gordon 1927, p. 5; 1927*a*, p. 72 etc.). Brit. Mus. (Nat. Hist.), Dept. Palaeont., Reg. no. V.53904.

Paratypes. The specimens figured in Pl. 119, figs. 1, 5, same locality and horizon as holotype, reg. nos. V.53903, V.53905.

Other material. Several examples in thin-sections made from the same rock sample.

This species is dedicated to the late Dame M. M. Ogilvie-Gordon (1864–1939), a pioneer Scottish woman geologist, distinguished for her work on the Dolomites, and a friend of Julius Pia. The material now described has been prepared from rock specimens collected by her.

COMPARISON AND EVALUATION

Aciculella is a somewhat problematic dasycladacean fossil: it can only be evaluated by comparison with other genera now to be considered.

Acicularia is a common Tertiary micro-fossil. Species are represented by solid or occasionally hollow calcareous bodies or spicules, elongate-cuneiform longitudinally, showing various shapes in cross-section, and set with numerous small peripheral spherical cavities (Pl. 118, fig. 2). At first regarded as animal in origin, their algal origin was indicated by Munier-Chalmas (1877), who recognized them as the dissociated radial segments of the calcified terminal discs of an alga similar to the living *Acetabularia* or 'Mermaid's wine-glass' (Pl. 118, fig. 4). There is one surviving living species of *Acicularia*, and this is regarded taxonomically as a section of *Acetabularia* by botanists (Egerod 1952), but palaeontologists, with the much greater importance of *Acicularia* over *Acetabularia* in the fossil record in mind, maintain it as distinct.

Shorter spicular bodies referable to *Halicoryne* have also been described from the Tertiary (Valet and Segonzac 1969).

Associated with *Acicularia* in the Tertiary are the flattened or spherical solid calcareous sporangial bodies of *Terquemella*. These are known to have originated from dasycladacean genera of normal tubular form without reproductive discs (Morellet and Morellet 1913, 1922). In the Mesozoic, however, calcareous sporangial bodies of variably intermediate form between the two occur, and are usually referred to *Acicularia* s.l., their generic origins being quite uncertain (some may be referable to *Halicoryne*). This difference in age and morphology between *Acicularia* s. str. and *Acicularia* s.l. has led to considerable confusion amongst those not closely familiar with this problem.

In considering the Triassic *Aciculella bacillum* Pia thought it highly improbable that it came from an alga with the very specialized organization of *Acicularia* s. str. ('which seems to have developed from *Terquemella* in late Cretaceous times only'; Pia 1930, p. 180). This was a strictly morphological recognition of the nature and geological age of

true *Acicularia* spp. However, I have since pointed out (Elliott 1968) that the reproductive disc, which in *Acetabularia* and *Acicularia* s. str. is a choristospore development, is found also in *Clypeina* (Permian-Oligocene), where it is probably a cladospore development. In other words, it is evidence of the achievement of similar morphology by an earlier, more primitive alga. Moreover, in the living species *Acetabularia clavata* Yamada and *A. tsengiana* Egerod, the lightly calcified terminal reproductive rays are not united to form a disc, but are largely separate (Egerod 1952). If heavily calcified, these would give rise to structures like *Aciculella*. Such a development may well have existed in extinct cladospore genera, and would be represented by dissociated fossil elements. If, therefore, Pia's rejection of *Aciculella* being similar in origin to *Acicularia* s. str. is to be supported, it must be on other grounds, and this is further dealt with below, as is his observation that *Aciculella* shows no pointed termination as in *Acicularia* s. str.

Holosporella (Triassic) and *Atractyliopsis* (Permian, ? Carboniferous) were interpreted by Pia (1930, 1937) as the remains of endospore dasycladaceans whose sole calcification was around the reproductive elements or sporangia (cf. text-fig. 1). These lay peripherally within the stem-cell, the exterior of the stem-cell and the outer branch-systems being uncalcified and hence quite unknown. The fossil thus consists of a hollow cylindrical arrangement of hollow spheres with calcified walls, adjacent, touching, or fused to varying degree (and with a very variable amount of secondary calcification, depending on subsequent diagenesis) (Pl. 118, fig. 3; Pl. 119, fig. 4). This apparently improbable interpretation is supported by two pieces of evidence. One is the Triassic species *Diplopora phanerospongia* Pia (Pl. 118, fig. 5), a diplopore showing normal heavy calification of both stem-cell and detailed trichophore branch-systems, but also showing calcified peripheral sporangia within the stem-cell cavity, as postulated for *Atractyliopsis* and other genera. Due to the waxing and waning stem-cell morphology of *D. phanerospongia*, accidental post-mortem insertion of originally separate and distinct straight calcareous algal structures one within the other (cf. Elliott 1968, pl. 24, fig. 2) is impossible. The endospore nature of this diplopore is thus authenticated. This vital species, known only to Pia from a Museum specimen, has now been rediscovered in the Upper Triassic, and other new similar species described (Ott 1967, Fenninger 1969).

The second point is from the known ontogeny of living dasyclads. Here the large nucleus is housed within the holdfast or basal portion throughout most of the growth of

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EXPLANATION OF PLATE 119

Figs. 1, 2. *Aciculella ogilvie-gordonae* sp. nov. 1, Oblique-transverse thin-section, paratype, ×93. 2, Longitudinal section, ×50. Upper Permian, Bellerophon Limestone; Plesch d'Inez, Grödener Valley, South Tirol, N. Italy. Reg. no. V.53903.

Fig. 3. *Aeolisaccus dunningtoni* Elliott: longitudinal thin-section, ×330. Small example showing initial spherical chamber. Upper Permian, Bellerophon Limestone; Plesch d'Inez, Grödener Valley, South Tirol, N. Italy. Reg. no. V.53903.

Fig. 4. *Atractyliopsis lastensis* Accordi. Thin-section of fragment, ×110, for comparison with *Aciculella ogilvie-gordonae* in the same matrix and rock sample. Upper Permian, Bellerophon Limestone; Plesch d'Inez, Grödener Valley, South Tirol, N. Italy. Reg. no. V.53906.

Fig. 5. *Aciculella ogilvie-gordonae* sp. nov. Transverse thin-section to show central as well as marginal sporangial bodies, paratype, ×160. Upper Permian, Bellerophon Limestone; Plesch d'Inez, Grödener Valley, South Tirol, N. Italy. Reg. no. V.53905.

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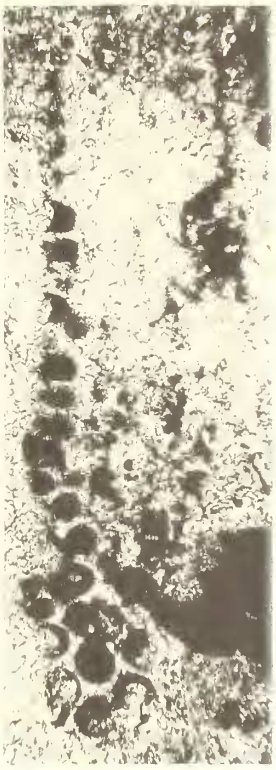

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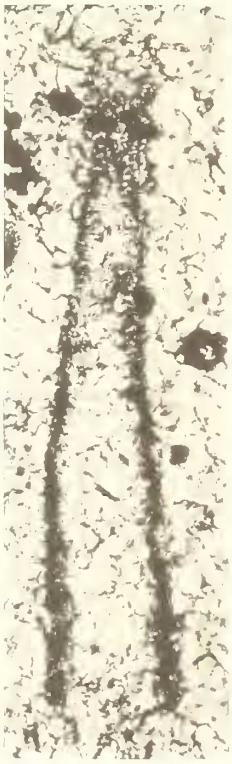

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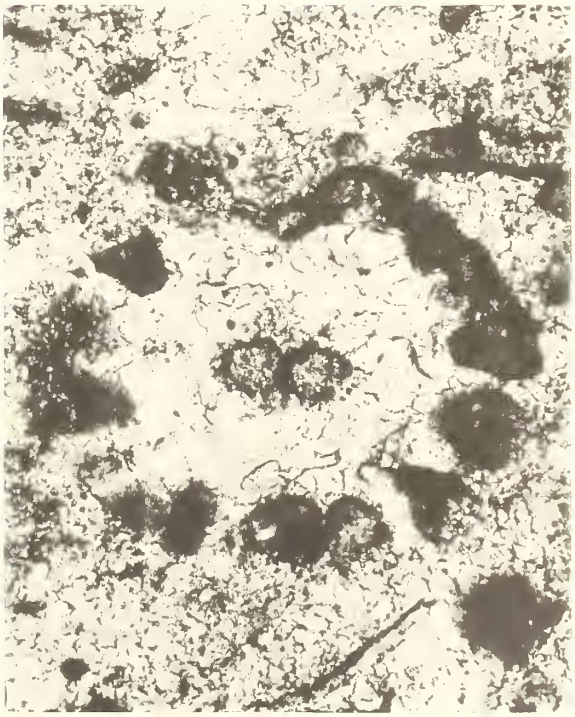

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ELLIOTT, *Aciculella* Pia